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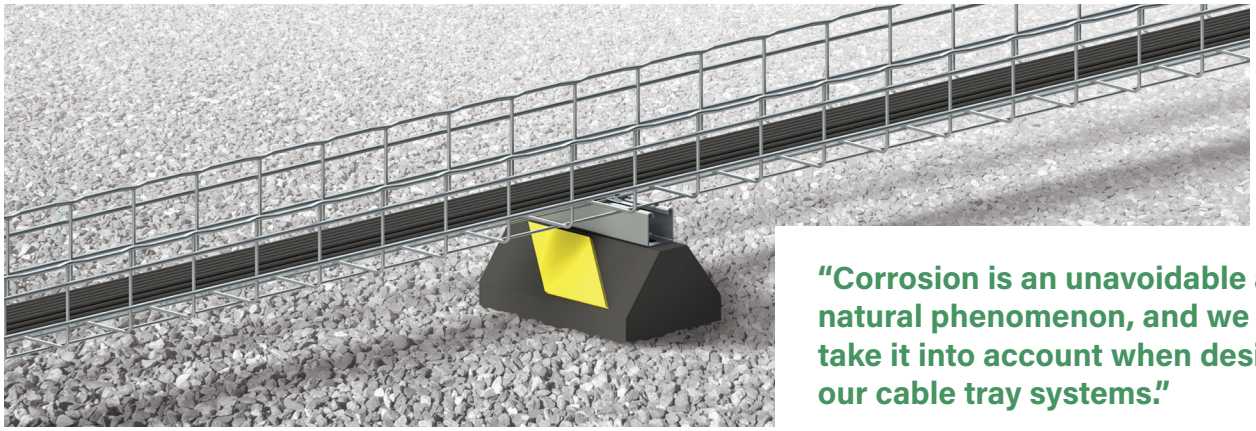
High-Performance Finishes:

A Comparison of Hot Dip Galvanizing (HDG) and High-Resistance (HR) Coatings



"Corrosion is an unavoidable and natural phenomenon, and we have to take it into account when designing our cable tray systems."

- Guillaume Luczkiewicz, Cablofil Marketing Manager

Introduction

The cable management industry has relied upon zinc coated steel as a mainstay for over 50 years. Zinc plated steel continues to be the most popular corrosion-resistant coating but is limited to indoor application. Outdoor applications for cable management are currently undergoing a significant shift in the finishing methods used for cable tray products. While Hot Dipped Galvanized (HDG) finish was once a common practice, it has presented challenges that are both costly and unsustainable. As a result, the industry is now transitioning towards a more innovative and sustainable solution – the High-Resistance (HR) finish. The HR finish not only offers superior sustainability and cost-effectiveness, but also results in a smoother, more durable product for installers and end-users, making it a favorable choice in the pursuit of continuous improvement and innovation.

In this white paper, we compare and contrast the two finishes, explore their usage in the cable management industry and provide context for the industry's transition to the HR finish.

Uncontrolled Corrosion: Cable Management's Pervasive Problem

Uncontrolled corrosion is a pervasive problem found in most metal applications where cable tray and accessories are exposed to harsh environments.

Environmental corrosion occurs when steel is in contact with a catalyst and oxygen, causing red rust (iron oxide) to form on the surface of the installation. Corrosion in these tough environmental elements often results in poor installation performance and negatively impacts the product's life expectancy.

Knowing that environmental corrosion is common in tough environmental applications, how can manufacturers best counter this natural phenomenon and create durable, long-lasting cable management solutions?

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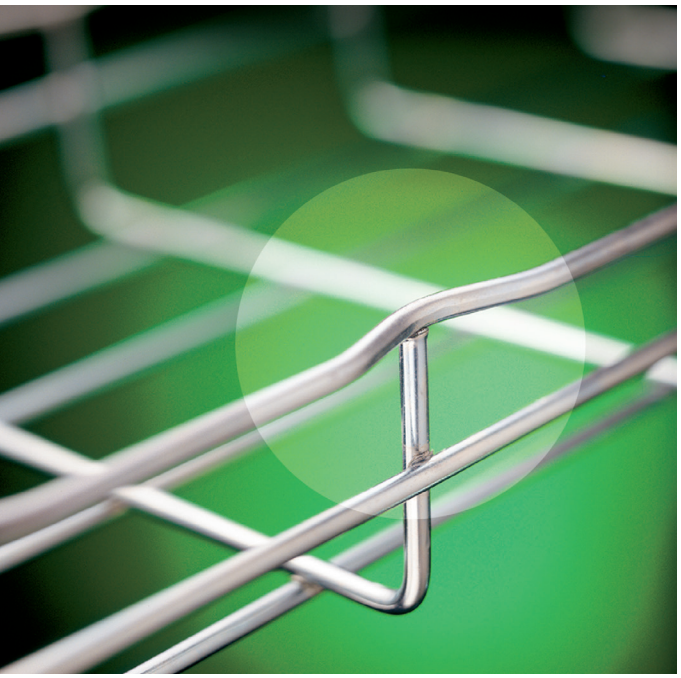
There are two types of protection available to combat corrosion when utilizing carbon steel:

- **Self-protecting barriers:** Structures such as stainless steel that, through passivation, have a protective chromium oxide layer that is less likely to chemically react with environmental elements.
- **Sacrificial barriers:** Chemical barriers, such as zinc, that cover the steel and oxidize before the steel starts to rust, creating a "self-healing" effect.



This paper focuses on two sacrificial barrier coating methods used in the industry: the common HDG finish and the newer HR finish.

Hot Dip Galvanizing (HDG) Finish: The Problem with HDG

Hot Dip Galvanizing (HDG) finish has existed for 150 years and is used in a variety of tough applications where products are exposed to harsh elements. HDG protects products by applying a layer of zinc to the surface of a metal. The coating provides excellent durability and longevity, ensuring optimal product performance and lifespan.

Despite its anti-corrosion capabilities, the problem with the HDG finish is threefold: it is not environmentally sustainable, it has a rough and costly application process and it is not as durable as alternative finishes that are now available.

High-Resistance (HR) Finish: Why Transition to HR?

Long used in the automotive industry as anticorrosive protection, the High-Resistance (HR) finish is becoming a popular protective choice for wire mesh cable trays. Anticipated to replace the HDG process, HR boasts several benefits including a more environmentally friendly production process and superior performance in harsh environments.

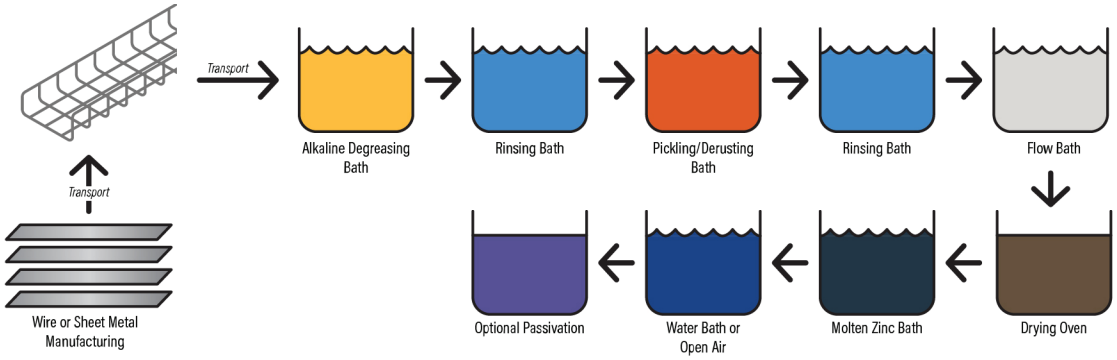
The transition to the High-Resistance (HR) finish presents a multitude of advantages while addressing the issues associated with HDG. The HR finish is more environmentally sustainable while offering a cleaner, safer and more cost-effective application process. The result is a smoother, more durable product that can deliver superior performance in various challenging industrial conditions – equivalent to or surpassing the performance of HDG.

Below, we provide an in-depth comparison of the two finishes by exploring their production processes, environmental impact, outdoor testing results, mechanical resistance performance, overall appearance, natural development and reparation processes.

Production Processes and Environmental Impact

The production of both HDG and HR involve submerging products in a molten zinc bath. However, there are several differences to the separate processes, rendering one more cost-effective, safer for workers and more environmentally sustainable.

The HDG Production Process



The process for HDG is intense and complex, both in time and in material resources. It also has a more detrimental impact on the environment and creates a more hazardous work environment than its HR counterpart.

Before the HDG finish can be applied, the metal product must be cleaned. This involves degreasing, pickling and rinsing the metal, usually with solvents or hydrochloric acid (HCI). This cleaning process produces water pollution, fumes and solid waste such as zinc ash and zinc matte.

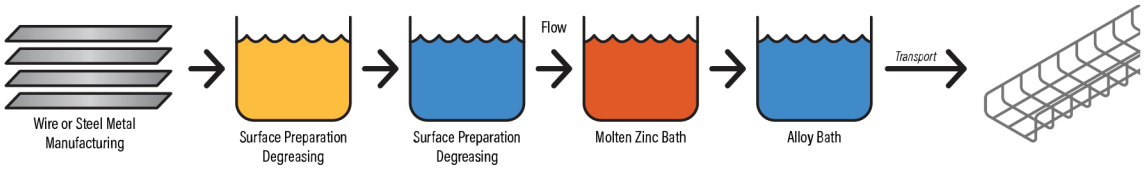
The HDG finish is created by dipping a product in a molten zinc bath where a reaction occurs between the metal and the hot zinc. This reaction begins to create a protective coat over the metal. When the product is removed from the bath, the zinc coating reacts with oxygen in the air to create another protective layer, one comprised of zinc oxide. Finally, the cooling zinc reacts with carbon dioxide to create a layer of zinc carbonate, completing the multi-layered, corrosion-resistant protective coating.

The bath of molten zinc must reach 450°C (850°F). These baths are energy-consuming and cannot be shut down on weekends or vacations. The high temperature and the zinc tend to eat away at the structure of the steel tanks, causing potential workplace hazards. This causes the tanks to have to be changed regularly to avoid the risk of workplace accidents and the spread of zinc on the production site, often requiring several weeks of shutdown.

Although some plants have been modernized to limit this pollution and recycle some of the waste, not all plants have the same level of prevention and control or are subject to the same standards.

In Europe, the production of HDG may still involve the use of lead, a practice that is not permitted in the United States. This inclusion of lead in the finish is inconsistent with the sustainability objectives of many countries, leading to a global effort to identify alternative finishes that have minimal environmental impact and do not contain any heavy metals or hazardous materials. The goal is to find a finish that offers a protective coating and durability comparable to or surpassing HDG, while aligning with sustainability standards and regulations.

HR Production Process + Environmental Impact



The HR process is more simplified and the reduction of the baths make it less impacting on the environment. The molten zinc bath also requires a temperature of only 280°C (536°F) -- much less than that of HDG. Also, HR's contribution to global warming is 7.1% lower than that of HDG and it releases six times less zinc oxide into the ground due to the stability of its anti-corrosion coating.

HR's eco-friendliness makes it an attractive finish for use in both the US and Europe, where it better aligns with the sustainability objectives and commitments of several countries. Additionally, the overall manufacturing, distribution, installation, use and end-of-life cycles for products coated in the HR finish have less environmental impact than those with HDG.

Outdoor Testing

When it comes to assessing the durability and resistance of outdoor installations, two types of easily reproducible and standardized tests have emerged: the salt spray test and the sulfur test. Each test has determined characteristics such as temperature, hygrometry and pollution that can be reproduced in a laboratory.

Since the manufacturing processes for wire mesh, metal cable tray or small accessories are slightly different, it is important to make a comparison in order to observe which finish lowers the performance of an installation.

SALT SPRAY RESULTS

The salt spray test is the most common and recognized test for cable trays. During this test, it was found that HDG products are a Class 6 with a minimum resistance of 550 hours while HR products are a Class 8 with a minimum resistance of 850 hours. At 850 hours, rust, including red rust, was spreading on the HDG product. By 2000 hours, a loss of mass was noted, making the product no longer compliant.

At the same 850 hours, the HR finish product demonstrated only white rust spread, with no red rust showing. By 2000 hours, minimal to no loss of mass was indicated, making the product still compliant at this level and outperforming the HDG product.

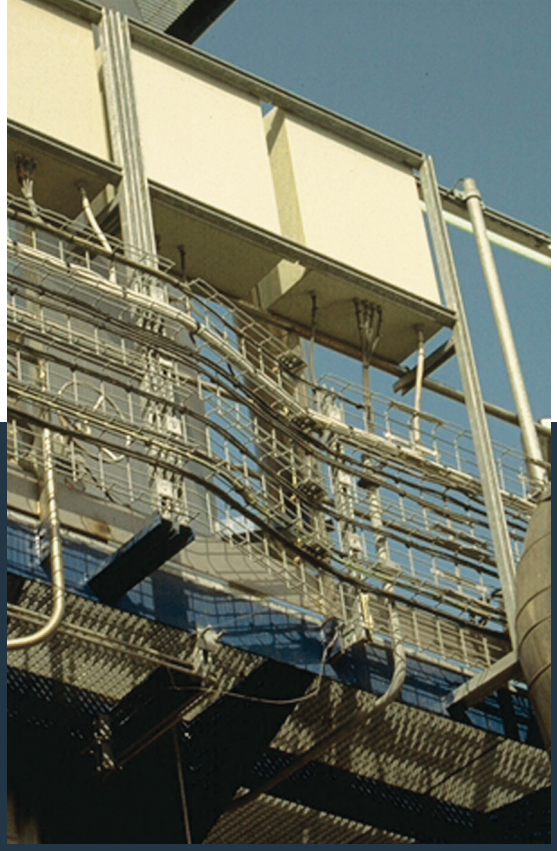
SULFUR DIOXIDE TEST RESULTS

The sulfur dioxide test is an excellent complementary test to perform in the laboratory to assess product corrosion in harsh environments. During this test, at 24 hours red rust could be seen on more than 5% of the HDG finish product. At the same 24 hours, no red rust was present on the HR finish product.

When testing was performed specifically on cable tray, red rust was seen at 384 hours with the HDG finish product. During the same test, red rust did not appear for the HR finish product until 456 hours, demonstrating that the HR finish can withstand this type of test better than HDG.

Mechanical Resistance

The mechanical strength of cable trays is determined by the metal's ductility, yield strength, elongation at break and weldability. The protection or coating does not influence the mechanical strength. However, the thickness and porosity of the finish does have an influence on the product's friction, corrosion and load capacity.



- **FRICTION:** The porosity and friction coefficient of the HR finish is slightly lower than that of the HDG finish. As a result, there is less dust creation on HR surfaces and the cables slide better, resulting in easier cable pulling.
- **CORROSION:** The zinc layer on HDG products is much thicker than HR. The thicker coating can cause the surface to be more brittle and prone to cracking. These cracks can create opportunities for uncontrolled corrosion to occur, decreasing product performance and lifespan.
- **LOAD CAPACITY:** On average, the HDG finish makes cable trays 7% to 10% heavier than HR finish products. This increased thickness results in a reduced load capacity and higher transporation costs and emissions.

Appearance

The appearance of HDG coating on a product varies depending on the metal. Many steel products containing phosphorus (P) are more reactive, resulting in a matte, mottled or rough appearance.

During the molten zinc bath, residual zinc droplets, pimples, beards, veils or drips can form on the HDG surface. This excess zinc can potentially damage cables and need to be manually removed, which is a time-intensive process. It is usually difficult to create HDG-coated trays without any flakes.

In addition to excess zinc, sometimes the thickness of the HDG coating can be problematic. In some cases, products and accessories cannot be mounted because of excessive HDG thickness.

With the HR finish, product appearances range from smooth with very few irregularities to matte with a low gloss appearance. On some HR products, slight dullness, veils, white halos or blackening on the end of the wire may be visible. These visual imperfections do not have an effect on the product's performance or lifespan. The HR finish also creates a smoother coat on the product that does not require removal of sharp zinc droplets.

Natural Development

Over time, the glossy appearance of HDG diminishes. If water stagnates on the surface, whitish stains may appear. This white rust is only cosmetic and can be removed with a pressure washer.

For HR, after a few weeks of manufacturing the color becomes more homogenous as white or black marks disappear. The product may also be sensitive to white rust with slight traces of red rust on exposed ends of the wire due to cuts during the manufacturing process. However, this red rust is only cosmetic – no loss of mass will occur. Eventually, the self-repair process takes place and the product will matte over time with the cut ends becoming covered in a grayish protective coating.

TARNISH ON WIRE

WHITE VEIL

BLACKENING ON END OF WIRE

WHITE HALOS ON THE WELD

The "Self-Healing" Reparation Effect

Both the HDG finish and the HR finish have the advantage of a "healing" effect on cuts made to the wire. This process works by hindering the appearance and progression of corrosion with a thin layer of naturally occurring oxides that appear on the surface of the coating. These oxides effectively inhibit corrosion in its initial stages and create a protective, compact whitish layer that prevents the progression of advanced corrosion stages.

Cut edges are typically the first areas to be protected by this zinc galvanic effect. As time passes, these cut edges are "healed" and are further protected from corrosion by the oxides that gradually cover the edges. This layer of oxide protection can swell and extend to cover adjacent areas that may be missing the coating due to imperfections acquired during installation, such as accidental surface scratches.

Although both finishes exhibit this healing effect, the HR finish offers a more robust reparation process that can significantly prolong the lifespan of the product, including where bends and folds are made. The HDG finish has a healing effect, but it is more limited and the product is prone to cracking when bends or folds are made during installation.

It is important to note that HR, DC, stainless steel and HDG products can be mixed without difficulty and with negligible risk of galvanic corrosion. However, the performance of the system will be limited to the characteristics of the HDG finish.

Conclusion

In conclusion, the cable management industry is witnessing a notable shift from the traditional Hot Dipped Galvanized (HDG) finish to the High-Resistance (HR) finish. While HDG has been a longstanding practice, it presents sustainability and durability challenges that have prompted the industry to seek alternative solutions. The HR finish offers a more innovative and sustainable option, delivering superior performance, cost-effectiveness and durability for installers and end-users. Through a detailed comparison of the two finishes, it becomes clear that the HR finish is a favorable and future-forward choice for the cable management industry.

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